Investment of Regenerative Thermal Oxidizer and Process Oven Heat Recovery

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ABSTRACT

Ball Metal Beverage Container Corp. operates an aluminum beverage can manufacturing plant at Wallkill, NY. In 2004 a new Regenerative Thermal Oxidizer (RTO) was installed to control emissions from process cure ovens. An incentive from the New York State Energy Research and Development Authority (NYSERDA) was instrumental in this project, designed and implemented by MEGTEC Systems Inc., to recovery 1.9 MMBtu/hr from the RTO and reuse in the manufacturing process. During the first year of operation, the system recovered 1.3 MMBtu/hr. The under-performance was due to particulate buildup on the heat exchanger. This paper discusses hurdles and strategies to deploying RTO heat recovery, critical roles played by MEGTEC and NYSERDA, project results, lessons learned, and how the project affected Ball's energy efficiency program.

Introduction

Ball Corporation (Ball) is a provider of metal and plastic packaging for beverages, foods and household products, and of aerospace and other technologies and services to commercial and governmental customers. Founded in 1880, Ball stock is traded on the New York Stock Exchange under the ticker symbol BLL.

The Ball Wallkill, New York plant (Wallkill) opened in 1972, and was acquired by Ball in 1998. Three high-speed lines produce several different sizes of aluminum beverage cans. In general, the plant operates continuously about 51 weeks per year, although there are various down times for can size changes and maintenance. In 2008, the plant produced 1.4 billion cans.

Background

A two chamber, 25,000 SCFM rated regenerative thermal oxidizer (RTO) made by MEGTEC (named the Cleanswitch), was installed in 2004 at the Wallkill plant for continuous air pollution control. The RTO was installed for formaldehyde emissions control, identified through a Best Available Control Technology (BACT) evaluation to comply with a New York State emission limit. Volatile organic compounds (VOCs) are also controlled by the RTO.

The RTO inlet is exhaust from seven ovens which cure interior and exterior can coatings. The average RTO inlet characteristics are: 15,000 SCFM; 27 lbs/hr hydrocarbon load; and 326˚F. The average RTO outlet characteristics are: 16,200 SCFM; 0.3 lbs/hr hydrocarbon (for a destruction efficiency of 99.1%), and 341˚F (before installing the project). The RTO combustion temperature is 1,450˚F. Until the heat recovery project was implemented, the RTO exhaust was vented directly to atmosphere.

Liquid thermal process loads at the plant include three beverage can washers with heat stages and heated soluble oil used in the can draw and ironing forming process. A closed-loop 5.5 MMBtu/hr (with same backup unit) non-contact hot water heating system was installed in 2002 to replace flame-tube direct heaters on the beverage can washers that were not ideal for production quality or energy efficient. The new hot water heating system also heats the soluble oil which was formerly accomplished through direct electrical heating. The hot water loop heats the process loads through non-contact, plate and frame heat exchangers. The average hot water supply temperature is 200˚F and the return temperature is 160-170˚F.

Ball is a charter member of EPA's Climate Leaders program, to reduce Greenhouse Gas (GHG) emissions. Their goal is to reduce the intensity of GHG emissions by 16% in 2012. Their primary strategy to achieve the reduction goal is to invest in energy efficiency projects such as the heat recovery. Ball investigated heat recovery in 2004 with MEGTEC. Heat recovery previously had not been installed at North American Ball aluminum can manufacturing plants (12 with RTOs) due to the long payback, lack of technology application experience, and general performance uncertainty. In summer 2006 we re-visited the project, and collaborated with Ball Europe employees to learn from their oven/RTO heat recovery experience, which had been installed to comply with regulatory requirements.

The budgeted project cost for the Wallkill heat recovery project was $396,000. To help with the project payback and thus obtain internal capital funding, Ball applied to the New York State Energy Research and Development Authority (NYSERDA) for a $146,000 incentive to install oven/RTO heat recovery. The application was proposed as an underutilized technology and process improvement with an energy benefit (PON No. 998). The project objective was to demonstrate the oven/RTO heat recovery technology application, performance, and payback. NYSERDA and Ball subsequently signed an incentive agreement in April 2007. Had Ball not received the NYSERDA incentive, the project might not have been pursued, especially since energy prices were decreasing from the 2006 spike when the project was scoped. In addition, Ball was motivated to obtain the NYSERDA incentive due to other positive attributes in working with NYSERDA. MECTEC was chosen as the contractor primarily because they had RTO heat recovery experience, because they had designed and installed the RTO at the plant, and because Ball had good, previous experience working with MEGTEC.

Project Description

Figures 1 illustrates the heat recovery system. The heat recovery is accomplished indirectly, in that the waste heat is transferred by non-direct contact to a closed loop system. In summary, the project consisted of using a 40hpdriven fan, and face/bypass dampers in the existing RTO exhaust stack, to force hot exhaust air through a six-layer deep fin and tube, mild steel, heat recovery coil (insulated and clad), and returning the cooled air to the existing exhaust stack. The dampers are electrically actuated, and the damper and fan are controlled by the coil's outlet water temperature. A 15hp driven pump recirulates the thermal fluid (water/glycol) through the heat exchange loop. The heat is transferred through a plate and frame style heat exchanger (183 square feet of surface area) to the plant hot water loop that supplies heat to the beverage can washers and soluble oil. The heat exchanger is located on the return side (after passing through the washer and soluble oil heat exchangers) before entering the hot water heater for reheat. The heat recovery system is controlled with programming done in the RTO PLC, and an added screen to the existing control panel. Ancillary equipment includes a roof-mounted 80-

gallon carbon steel expansion tank with level switch; slip stream filter package including a filter housing, shut-off valves, drain valves, vent valve, pressure gauges, and filter cartridges to provide continuous filtration of the thermal fluid; carbon steel horizontal drain tank; fill and drain pump; and bypass and manual metering system to bypass the boiler water into the heat exchanger.

The heat recovery system design is based on the following parameters:

- Flow rate of 300 GPM
- Hot water loop return temperature of 160˚F
- Hot water supply of 200˚F
- 24 hours/day, 7 days/week, 50 weeks/yr operation (8,400 hours per year)
- $1.20/therm natural gas
- $0.1335/kWh

The design performance is the following:

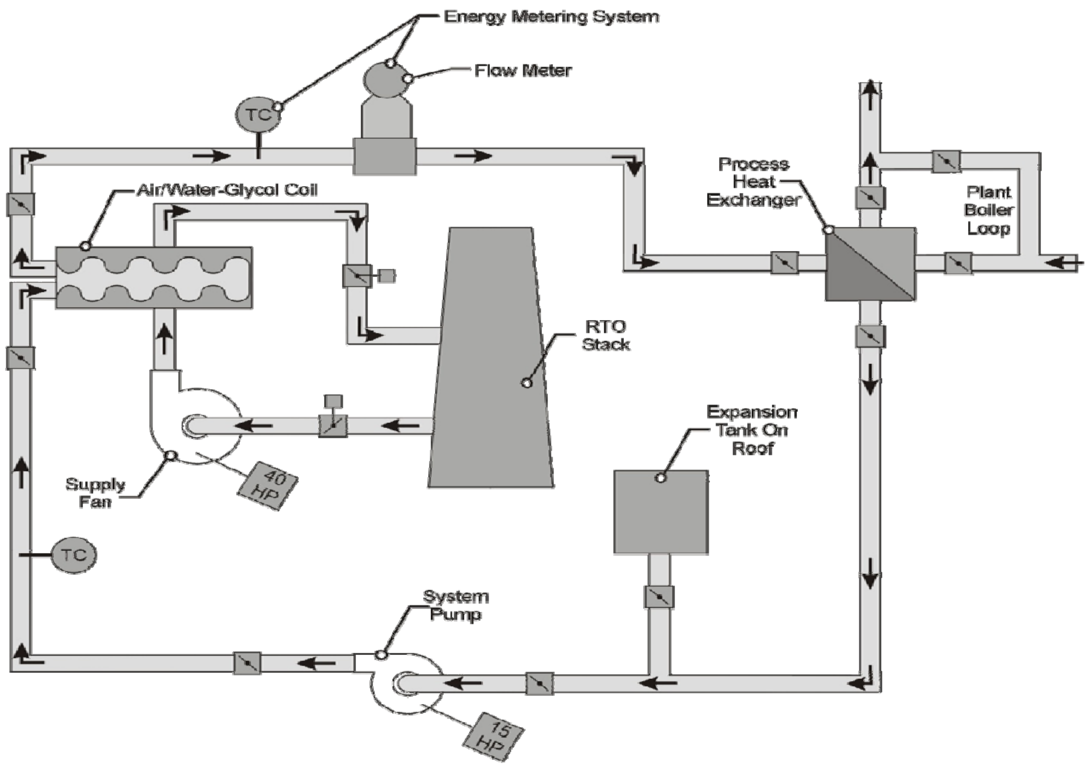
15,000 SCFM * 1.08 * (341˚F – 224˚F) = (1.9MMBtu/h) * ($12/MMBtu) *(8,400 hrs/yr) = $191,520/yr

Assuming the hot water heat efficiency was 85%, the net estimated gas savings were $191,520/yr / 0.85% = $225,317yr

Electrical usage = (18kw {avg load} x .746 /.88 = 15.3kW/hr fan +9 kW {avg load} x .746/.87 = 7.7kW/hr pump) x $0.1335/kWh = $3.07/hr x 8,400 hrs/yr = $25,792/yr

The net expected energy savings($) were $225,317/yr (gas savings) – $25,792 (electric) = $199,525/yr

Figure 1. Oven Heat Recovery System



Installation

Ball issued the purchase order to MEGTEC in July 2007. Much of the heat recovery equipment (fan, heat exchanger, pump, etc). was pre-constructed on a skid. Piping installation and equipment on-site arrival began November 2007, and the system start-up occurred January 25, 2008. Ball complied with NYSERDA's request to publish monthly progress reports, which summarized the planned work, progress, and problems. The progress reports were published April 2007-March 2008. There were no major problems during the primary installation period. However, there were various startup and installation close-out issues that affected the system performance during February and March. MEGTEC was responsible for collecting and managing system performance data through the RTO PLC, whereas Ball was responsible for data management and reporting.

Results

NYSERDA requested that Ball implement a monitoring plan to demonstrate the system performance. The monitoring plan consisted of measuring the thermal fluid flow rate through the primary exchanger, and measuring the thermal fluid supply and return temperatures. The data was collected by the RTO PLC and routed to the Ball InfinityQS information system, which is the plant's production quality data management system. The system performance data is collected on 5-second intervals and then averaged as a single data point for a 15 minute period. A report was written in InfinityQS to graphically present the data, and allow Ball to define the data date range and review the system performance. The monitoring plan was fully implemented March 17, 2008. Table 1 one shows the system performance from March 2008 to March 2009. Figure 2 (March 2008-August 2008) and Figure 3 (September 2008-March 2009) graphically show the system performance (average BTUs per 15 minute interval) directly taken from InfinityQS (the data management and reporting system). The results are discussed in the following section.

Table 1. Heat Recovery Performance, March 2008-March 2009

Date	Avg MMBtu/hr	Total MMBtu/Period	Net MMBtu/Period[c]	Net Savings ($)[d]
Mar 18-08[a]	2.05	1,525	1,794	18,260
Apr-08	1.51	1,087	1,279	13,647
May-08^	1.06	789	928	10,776
Jun-08	1.70	1,224	1,440	16,471
Jul-08^	0.85	632	744	11,545
Aug-08	1.60	1,190	1,400	19,693
Sep-08	1.82	1,310	1,542	22,137
Oct-08^	0.78	580	683	6,821
Nov-08	0.91	655	771	7,108
Dec-08^	0.62	461	543	5,274
Jan-09	1.10	818	963	8,071
Feb-09^	0.47	316	372	3,115
Mar 17-08[b]	1.72	1,280	1,506	12,620
Average	**1.25**			
Total		**11,869**	**13,963**	**155,537**

[a]March 18

[b]March 17

[c]assumes existing heating system efficiency of 85%

[d]based on the all-in monthly cost of gas (cost of system electricity is excluded)

^heat exchanger cleaning

Figure 2. Heat Recovery Performance, March 18, 2008 – August 31, 2008

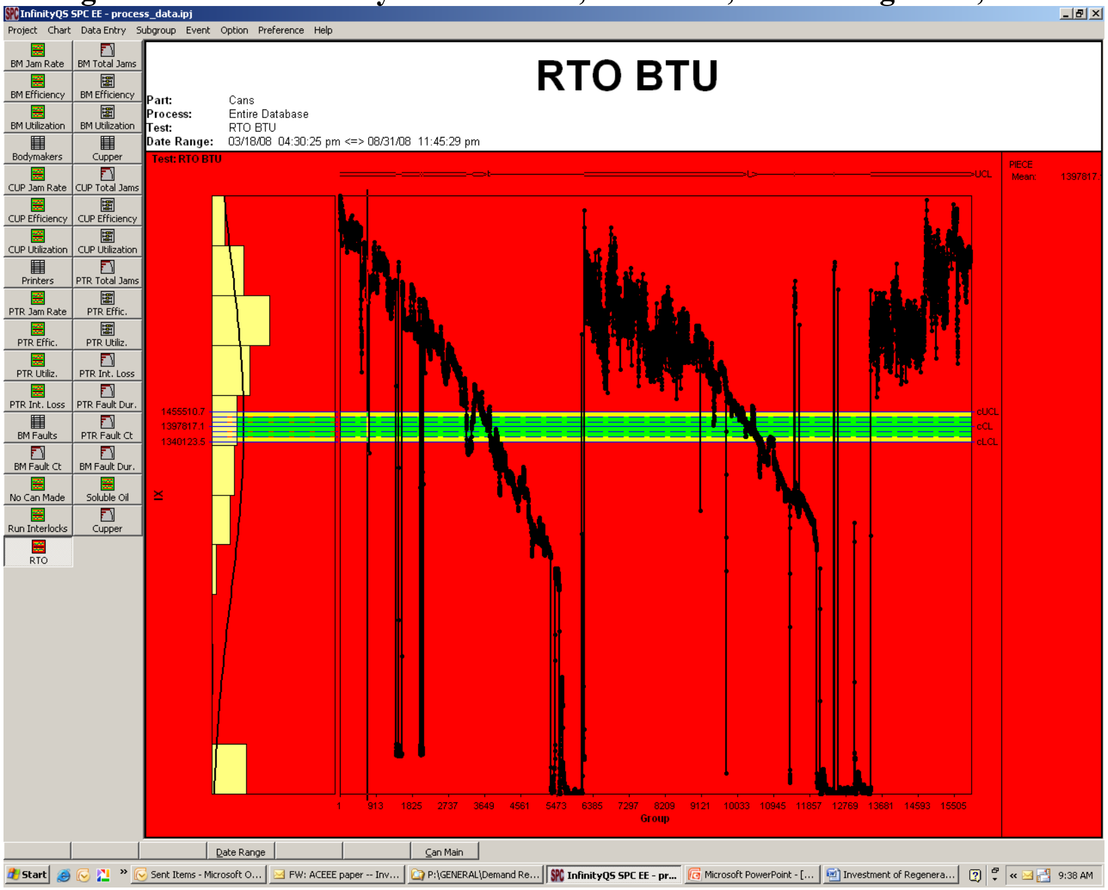
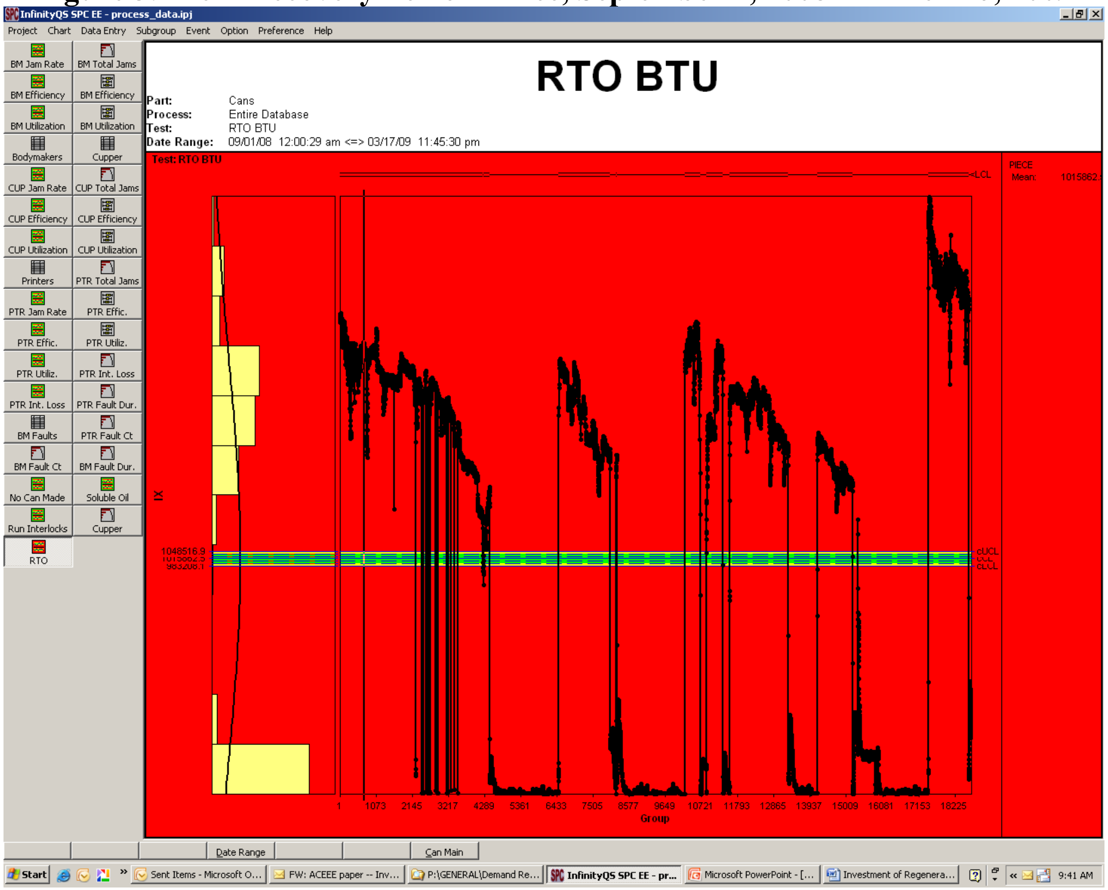


Figure 3. Heat Recovery Performance, September 1, 2008 – March 17, 2009



Discussion

In general, comparing the system performance in Table 1 to the design conditions outlined in Section 3.0, the system under performed in comparison to the design. The main reason the system under performed was due to particulate buildup on the RTO heat exchanger, which reduced the efficiency and resulted in bypass time, where the RTO operated without the heat recovery system in operation. Table 1 shows the exchanger was cleaned five times between May 2008 and February 2009. The following is a discussion of associated operating challenges and attempted solutions.

During February and March 2008, excluding the system "start-up/installation hiccups", the system appeared to perform as expected. The RTO recovery load was close to the process load, so some turning of the hot water control was necessary. However, as shown in Figure 2, the performance in May declined to the point that the thermal fluid temperature was less than the hot water system return temperature . In May 2008, the system was shutdown, and MEGTEC cut access doors to observe the hot and cold faces of the exchanger. All heat exchanger surfaces were covered with a beige-colored, non-dense particulate.

The particulate was sampled and analyzed by both MEGTEC and Ball, and determined to be primarily organic. In addition, MEGTEC performed a bake-out test to determine the ignition temperature of the particulate. Subsequently the coil was cleaned with compressed air, the heat recovery system restarted in early June, and performance improved. An RTO bakeout was conducted to ensure the RTO was performing as designed. However, the heat recovery performance steadily declined again, and the system was shut down toward the end of July. At that point, the heat exchanger was cleaned again and a sonic horn was installed to prevent particulate buildup. It was suspected that the sonic horn would slow down the particulate buildup so that maybe cleaning would be required annually. The heat recovery system performed better but then gradually declined and the system was shutdown again in October.

Further investigation (comparing RTO heat recovery at BPE and a new system started at Ball Milwaukee by MEGTEC) pointed the particulate might be from the 15 CFM in the RTO valve that is exhausted without being treated when the valve switches (every 180-seonds) the flow from one media bed to the other (which does not occur on a three-media bed RTO). Hot beverage can plant cure oven exhaust tends to precipitate a condensate when exposed to a cool surface. Subsequently, MEGTEC reduced the bed cycle time from 3 to 4 minutes, to theoretically reduce the mass loading by 25%. In addition, MEGTEC changed the operating logic to partially close a restriction valve in the heat exchanger inlet duct, so when the RTO valve switches, the flow to the heat exchanger is reduced by about 80%. The exchanger was cleaned again, the system restarted, and the previous performance pattern occurred. Another compounding problem was the thermal fluid pump seal began leaking. Pipe scale was likely occurring due to the thermal changes with the system up and down operation.

In February 2009 the heat exchanger was re-cleaned, the new filtration system was installed to clean the thermal fluid, and the RTO setpoint was raised from 1,450˚F to 1,600˚F. This is the standard operating temperature of the combustion chamber. It was suspected that the higher RTO combustion temperature would increase the destruction efficiency (reducing the particulate load) and increase the exhaust temperature through the exchanger, thus further reducing the particulate load. The additional energy put into the combustion chamber will be removed by the heat recovery system. Since re-start March 5, the data has been promising but additional time will tell if the particulate problem intensity has been reduced.

Conclusions

The RTO heat recovery system has averaged about 1.25 MMBtu/hr, below the 1.9 MMBtu/hr design. The under-performance is due primarily to particulate build up on the heat exchanger and the resulting down time to schedule and conduct cleanings, and implement solutions. MEGTEC has been very helpful in trouble shooting and supporting this particulate issue. Several corrective measures have been implemented by them to resolve or at least reduce the particulate problem. Related, the project has required much more plant support and labor than anticipated. On positive notes, Ball and MEGTEC have learned lessons from the Wallkill experience. For example, access doors to the heat exchanger (above and below) are now standard. The performance data acquisition, reporting, and management through the InfinityQS system have worked well, and are essential for system management. The RTO heat recovery operation has not adversely affected the plant production; the heating load not supplied by the recovery system is supplied by the existing hot water heating system, and the controls between the two systems operate in harmony. Considering the discussed challenges, the one year gas savings have been $155,537 minus about an estimated $18,000 additional electrical for the fan and pump operation, for a net cost savings of $137,537. The cost savings are affected by the overall lower actual monthly cost of gas and electric versus the cost of gas and electric during fall 2006 when the project was being developed. The actual one year heat recovery savings was

13,963 MMBtu versus a design of 18,776 MMBtu (1.9 MMBtu/hr x 8,400 hrs/yr / 0.85 existing heat system efficiency), or 74% of the design. Lastly, the net project GHG savings for the period was 743 metric tons C02e (net gas) minus 67 metric tons C02e (extra electric) = 676 metric tons CO2e.

In summary, Ball believes that heat recovery from the ovens/RTO makes sense from cost, energy, and environmental aspects, attributes of the triple bottom line that help define Ball's commitment to sustainability. Both Ball and MEGTEC have learned from the Wallkill experience which has helped in our pursuit of additional heat recovery projects. Maybe our experience can encourage others to recover waste heat and re-use in the manufacturing process. To that end, Ball and MEGTEC installed oven/RTO on a larger scale at the Ball Milwaukee plant in 2008, which is operating successful and according to design. Further, Ball applied to NYSERDA in July 2008 for another incentive to install oven/RTO heat recovery at our four-line aluminum beverage can plant at Ball Saratoga Springs NY, which has a 32,000 SCFM 3-chamber RTO. This project, designed by MEGTEC, will be Ball's most complex heat recovery project to date in that it includes converting the existing low pressure steam heating system to hot water, and incorporating heat recovery which will completely supply the plant liquid thermal demand.